Mixed Criticality Scheduling Applied to JPEG2000 Video Streaming over Wireless Multimedia Sensor Networks

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Outline

- Wireless Multimedia Sensor Networks (WMSNs)
  - Introduction
  - Applications
- Objectives of this work
- Mixed-criticality in context of WMSNs
- Testbed
- Experimental results
- Conclusion and Future works
Wireless Multimedia Sensor Networks

- Networks of wireless devices capable of sensing
  - Multimedia content (video, audio, still images)
  - Scalar sensor data (temperature, humidity …)

- With integrated components of
  - CMOS cameras
  - Microphones
  - Low-cost small scale imaging sensors

Difference with Wireless Sensor Networks
- most of WSNs measure scalar physical phenomena like temp., pressure, humidity and
- They require low bandwidth and are delay tolerant
Applications of WMSNs

- multimedia surveillance networks
- Road traffic monitoring
- Environmental monitoring
- Target tracking
- etc ...
Constraints in WMSNs

- limited computational power
- reduced memory
- Narrow bandwidth
- limited energy support
- etc ...

So, Image and video transmission over such networks is still an important challenge to address
Objective of this work

To address these issues, we apply

**Mixed-criticality Paradigm**

for efficient transmission of multi-layer JPEG2000 based image and video over such constrained networks.
Mixed-criticality in the context of WMSNs

- In wireless networks, wireless channel capacity varies due to:
  - e.g., interference from neighboring devices
- Hence, when channel quality is degraded, Why do we need to transmit all information (both critical and non-critical)?

  Don’t over chunk the Baby!!!

- JPEG2000 provides seamless progressive transmission by resolution and quality
• The MC nature of the wireless system arises from the fact that
  ○ Under high availability of bandwidth
    • transmit all information (all layers and resolution)
  ○ However, when the bandwidth is low
    • transmit only critical information
MC Principles

• We have a non-preemptive wireless communication channel
  ○ L criticality levels defined by bandwidth thresholds
  ○ Transmission of periodic frames

• \( B(l) \) is the available bandwidth at level \( l \)
  ○ \( B(l + 1) \leq B(l) \forall l \in [1, L] \)
  ○ The transmission time increases with criticality

\[ C_i(l) = \frac{N_i}{B(l)} \]
Worst Case end-to-end Response Time

Why does it matter?

• End-to-End response time impacts freshness and liveliness

• classical QoS approaches tends to
  • reduced QoE ... Less visual comfort when bandwidth is low

• Our goal with MC: continuity in visualization with lower image quality when bandwidth is low

Two classical approaches to deal with WCERT

• Trajectory
• Holistic
We apply the trajectory approach,

- It considers scheduling produced by all visited nodes along the path of a flow

- It has two components
  - max delay due to non-preemption
  - latest start time in the last node

- This approach provides a good upper bound on the WCERT in deterministic networks (e.g. LAN)

- However, in the context of wireless networks, the estimated available bandwidth always considered as the minimum available bandwidth ... which can be pessimistic
The Π-sense testbed

Components

• Raspberry pi
• WIFI dongle
• Babel
• JPEG2000
• WBBest
MC-wireless

1. Fixed priority for the sources
2. Criticality levels that corresponds to available bandwidth values

![Graph showing criticality levels](image)

- Level 1
- Level 2
- Level 3
Results

• When BW is low (crit. Level 3)
• Case of WCERT_3
  o Disconnect source 2
  o Transmit only critical frames from source 1
• BW = 0.2012Mbps
  o With MC – 0.3820s
  o Without MC – 0.8226s
• Trajectory approach
  o 0.62388s
  • Pessimistic … huh!

![Diagram](source1.png)
Conclusion and Future works

• An improved end-to-end response is achieved by adopting mixed-criticality scheduling scheme
  ○ In comparison with the classical case where all information exhibit the same level of information
    • This ensures freshness of the information
  • An interesting extension of our work can be
    ○ Applying our scheme to a larger network (Scalability)
      • By clustering and cluster heads
THANK YOU!